CLAIMS

1. A process for generating steam for downhole injection in a steam flood process for oil recovery, said process comprising:

(a) heating a de-oiled produced water stream containing water, dissolved solutes, and dissolved gases, said dissolved solutes further comprising at least one molecular species which is at low ionization levels when in solution at around neutral pH,

(b) raising the pH of said heated, produced water stream to maintain the solubility of said molecular species therein at a selected concentration factor,

(c) pressurizing and directing said produced water stream to a circulating concentrated brine in a produced water evaporator, said evaporator having a plurality of heat transfer surfaces,

(d) distributing said circulating brine across a first surface of at least one of said plurality of heat transfer surfaces to generate a steam vapor suitable for injection into a selected geological formation to fluidize oil,

(e) discharging at least some of said brine as an evaporator blowdown stream,

(f) distributing steam from a watertube boiler across a second surface of at least one of said plurality of heat transfer surfaces to condense said steam as a condensate,

(g) returning said condensate to said watertube boiler for steam production, and,

(h) discharging at least some of said condensate as a boiler blowdown to the produced water evaporator.

2. The process as set forth in claim 1, wherein said dissolved solutes further comprise hardness cations in a quantity that produces a scale deposition on said first surface of said heat transfer surfaces at said selected concentration factor.

3. The process as set forth in claim 1, wherein said produced water stream further comprises at least some non-hydroxide alkalinity.

4. The process as set forth in claim 1, wherein the pH is raised to between 10 and 11 and maintained in said evaporator circulating brine.

5. The process as set forth in claim 1, wherein the pH is raised to between 11 and 12 and maintained in said evaporator circulating brine.

6. The process as set forth in claim 1, wherein the pH is raised to between 12 and 13 and maintained in said evaporator circulating brine.

7. The process as set forth in claim 1, wherein the pH is raised to greater than or at least about 13 and maintained in said evaporator circulating brine.

8. The process according to claim 1, wherein the step of raising the pH is accomplished by addition of an inorganic base in aqueous solution, said base selected from the group consisting of sodium hydroxide, and potassium hydroxide.

9. The process as set forth in claim 3, wherein a portion or substantially all non-hydroxide alkalinity in said produced water stream is removed.

10. The process as set forth in claim 9, wherein the step of removing said non-hydroxide alkalinity, is further comprised of lowering the pH of said produced water stream to release at least some free carbon dioxide.

11. The process as set forth in claim 10, wherein the step of adjusting pH is accomplished by the addition of hydrochloric acid or sulfuric acid.

12. The process according to claim 1, wherein said produced water evaporator comprises a falling thin film evaporator, operating as a single unit, or operating in parallel, to generate said steam and said blowdown stream.

13. The process according to claim 1, wherein said produced water evaporator comprises a rising film or thermo-siphon evaporator, operating as a single unit, or operating in parallel, to generate said steam and said blowdown stream.

14. The method according to claim 1, wherein said heat transfer surfaces are tubular.

15. The method as set forth in claim 14, wherein said heat transfer surfaces are operated in a vertical position.

16. The method as set forth in claim 14, wherein said heat transfer surfaces are operated in a horizontal position.

17. The method as set forth in claim 14, wherein said heat transfer surfaces are designed for enhanced heat transfer.

18. The process according to claim 1, wherein said produced water evaporator comprises falling film and rising film in a combined process, operating as a single unit, or operating in parallel, to generate said steam and said blowdown stream.

19. The process as set forth in claim 14 wherein said circulating brine is heated on the interior of the tubes.

20. The process as set forth in claim 14 wherein said circulating brine is heated on the exterior of the tubes.

21. The process as set forth in claim 1, further comprising distributing said circulating brine across a first heat transfer surface of at least one of said plurality of heat transfer tubes to generate a steam vapor.

22. The process as set forth in claim 21, further comprising collecting said steam vapor and directing it to an injection well present in a selected geological formation, to produce an oil and water mixture.

23. The process as set forth in claim 21, wherein said steam vapor generated is at a pressure ranging from 200 to 1600 psig.

24. The process as set forth in claim 1, further comprising the step of treating said produced water evaporator blowdown stream in a zero liquid discharge process.

25. The process as set forth in claim 1, further comprising the step of injecting said produced water evaporator blowdown stream in a deep well for disposal.

26. The process as set forth in claim 24, wherein said zero liquid discharge comprises a steam driven multiple effect concentration and crystallization evaporator process to generate (a) high quality steam vapor and, (b) a high solute, high suspended solids slurry.

27. The process as set forth in claim 1, further comprising supplying said water tube boiler with de-ionized makeup water to produce said steam and a high solute containing blowdown stream.

28. The process as set forth in claim 27, wherein said de-ionized makeup water is produced by a reverse osmosis unit.

29. The process as set forth in claim 26, further comprising, dewatering said generated suspended solids slurry in a filter press or belt filter and, further comprising, recycling the filtrate back to the crystallization effect of the multiple effect evaporator.

30. The process as set forth in claim 24, wherein said zero liquid discharge comprises a steam driven crystallizer evaporator process to generate (a) high quality steam vapor and, (b) a high solute, high suspended solids slurry, and, further comprising, dewatering said generated suspended solids slurry in a filter press or belt filter and, further comprising, recycling the filtrate back to the inlet of the crystallizer evaporator.

31. The process as set forth in claim 27, wherein said de-ionized makeup water is produced by an ion exchange unit.

32. The process as set forth in claim 28 or claim 31, wherein the feed water utilized for de-ionized makeup water is fresh water.

33. The process as set forth in claim 2, wherein a portion or substantially all hardness cations are removed in a deionization zone.

34. The process as set forth in claim 1, wherein said molecular species is silica.